Comparison of Forest Canopy Height estimation from Lidar, InSAR and Very High Resolution Stereo Imagery highlights the advantages and alternatives for forest structure and biomass estimation in remote areas

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Figure 1

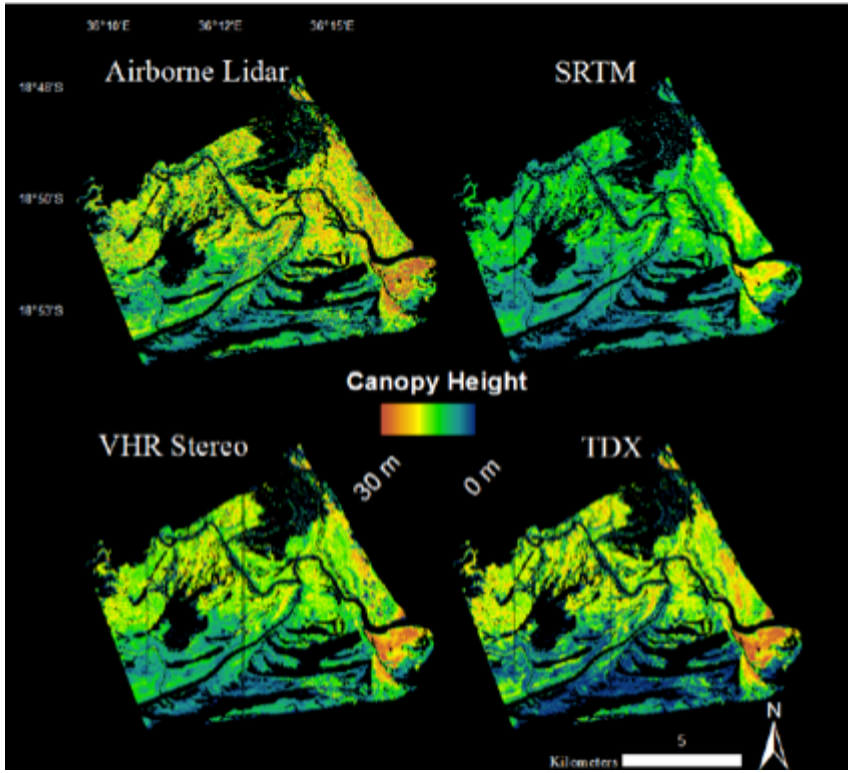
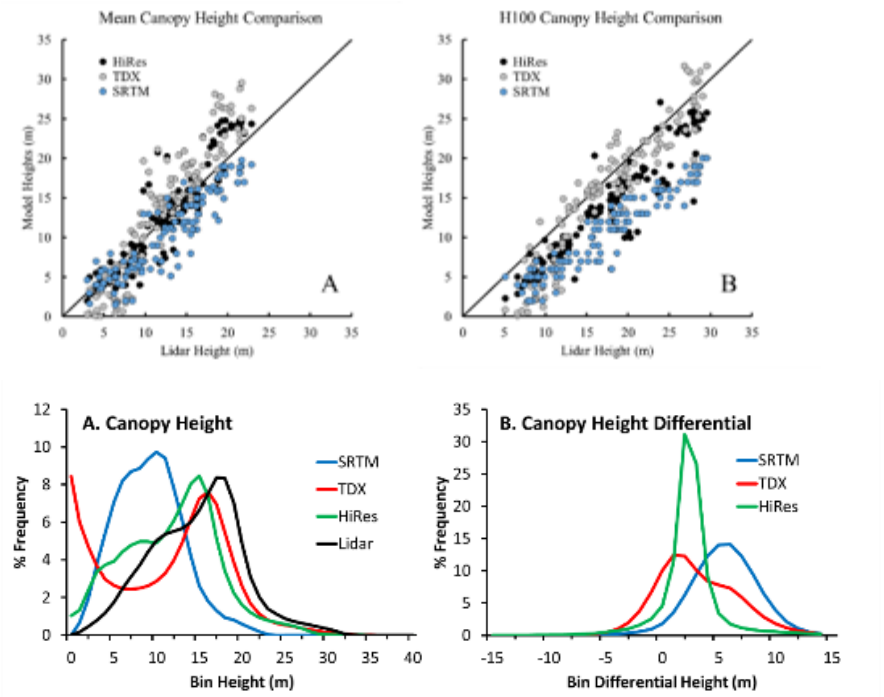


Figure 2



Results show the applicability and accuracy of Very High Resolution Stereo Imagery (VHR Stereo) InSAR data (from TanDEM-X and SRTM) to measure canopy height, canopy height changes, and estimate above-ground biomass and carbon stocks in forest ecosystems, such as mangroves.

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References:

- Lagomasino, David, Temilola Fatoyinbo, SeungKuk Lee, Emmanuelle Feliciano, Carl Trettin, and Marc Simard. "A Comparison of Mangrove Canopy Height Using Multiple Independent Measurements from Land, Air, and Space." *Remote Sensing* 8, no. 4 (2016): 327. doi: 10.3390/rs8040327;
- Lagomasino D, Fatoyinbo T, Lee SK, Simard M. High‐resolution forest canopy height estimation in an African blue carbon ecosystem. *Remote Sensing in Ecology and Conservation*. 2015 Oct 1;1(1):51-60. DOI: 10.1002/rse2.3
- **Authors/Collaborators not listed**: Carl Trettin, USDA Forest Service ; Marc Simard, NASA JPL

Data Sources: SRTM (Shuttle Radar Topography Mission) 30 m DEM, WorldView 1 Stereo data acquired through the NASA/NGA commercial data archive, TanDEM-X data, commercial airborne Lidar; **Acknowledgements:** "Digital Globe data were provided by NASA's NGA Commercial Archive Data (cad4nasa.gsfc.nasa.gov) under the National Geospatial-Intelligence Agency's NextView license agreement. TanDEM-X data was provided through the TanDEM-X science team membership, airborne Lidar was acquired through the USFS/CIFOR SWAMP program; Funding for this research was provided through the NASA Carbon Monitoring System project "Total Carbon Estimation in African Mangroves and Coastal Wetlands in Preparation for REDD and Blue Carbon Credits";

Technical Description of Figures:

Figure 1: This figure shows four canopy height models of mangrove forests generated from Airborne Lidar, SRTM Interferometric SAR (InSAR) data, Very High Resolution (VHR) Stereo and TanDEM-X (TDX) Polarimetric InSAR data. The aim of this study was to evaluate the accuracy and sensitivity of Interferometric SAR and Stereo photogrammetric datasets to canopy height with the aim of upscaling local estimates of canopy height and biomass from Lidar to much larger, National and potentially Global scales. The canopy height models (CHM) of the four datasets correspond well, although as shown in **Figure *2*** : TDX canopy heights CHMs exhibited a negative and positive bias respectively. The canopy height histogram distributions computed for all four CHMs (e.g., SRTM, TDX, VHR, and Lidar) exhibit two distinct patterns: negatively skewed distributions with peak frequencies clustered around each other, and a positively skewed distribution with a lower magnitude frequency. Lidar, TDX, and VHR CHMs all show similar maximum height frequencies between 15 and 18 meters that accounted for nearly 8% of canopy in the study area.

Scientific significance, societal relevance, and relationships to future missions: Mangroves and tidal wetlands have the highest carbon density among terrestrial ecosystems**.** Although they only represent 3 % of the total forest area (or 0.01 % of land area), C emissions from mangrove destruction alone at current rates could be equivalent to 10 % of carbon emissions from deforestation. The high C sequestration coupled with the high risk of destruction makes mangroves a prime candidate for carbon mitigation initiatives such as REDD and an important contributor to the Global Carbon Cycle. One of the main challenges in forests is measuring carbon, efficiently, effectively, and safely. Our goals are to develop the methodologies for, and produce the initial remote sensing products necessary to measure carbon stocks in Forests and Blue Carbon ecosystems. This research is also directly relevant to the upcoming NASA GEDI-Lidar Mission as one of the GEDI L4 products is to be a GEDI-TanDEM-X fusion dataset.

Positive Trend in Antarctic Sea Ice and Associated Changes in Surface Temperature

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Figure 1

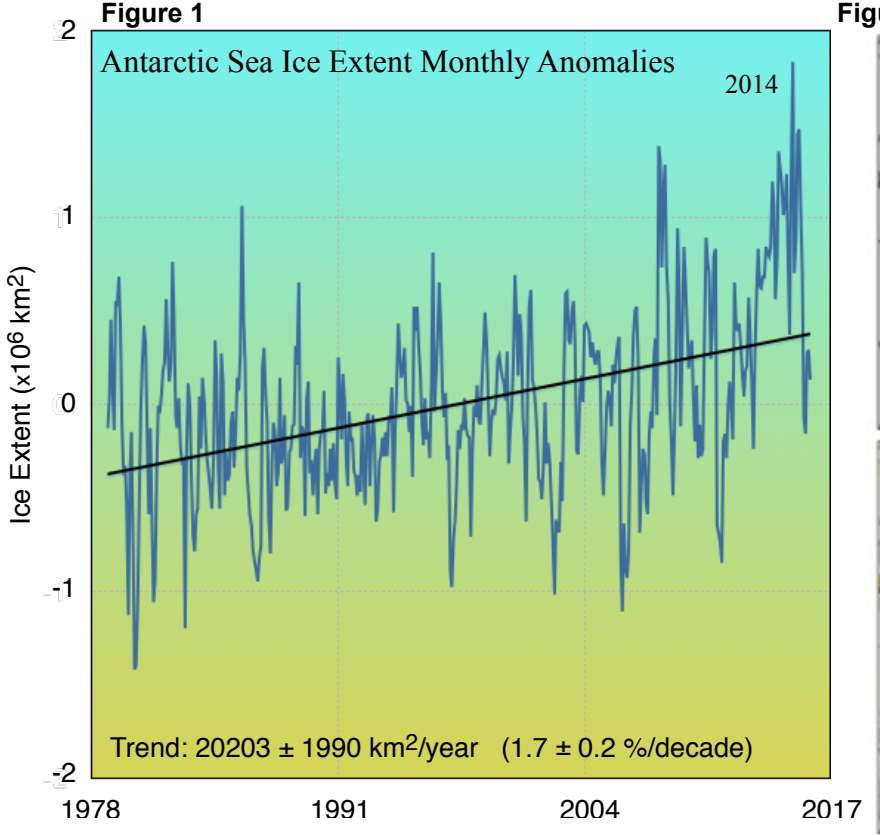


Figure 2

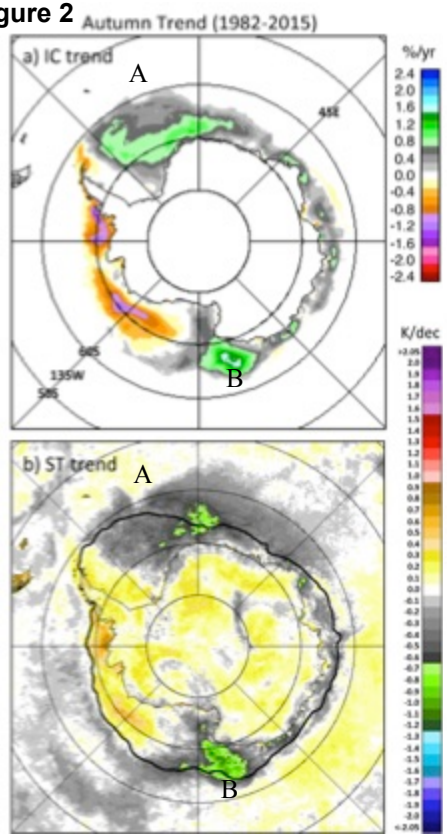
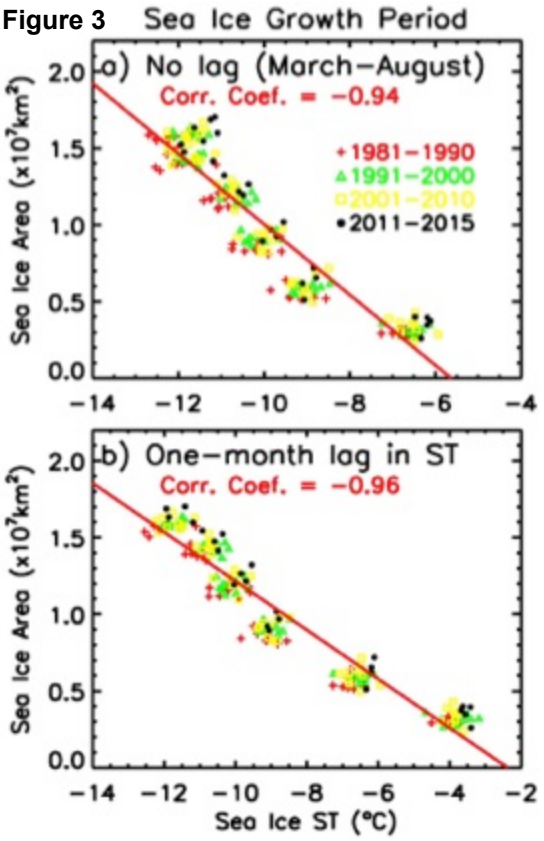


Figure 3



Trends in global temperatures have large regional variability and in the Antarctic the trend in surface temperature provides insights into the observed positive trend in the Antarctic sea ice cover. During the growth period in autumn the same areas (e.g., see labels A and B) where the trends in ice concentration are anomalously positive are also where the trends in surface temperature are anomalously negative. The correlation of surface temperature with ice area is very strong suggesting a strong influence of surface temperature on the positive trend in the Antarctic sea ice cover.

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References:

Comiso, J. C., R. Gersten, L. Stock, J. Turner, G. Perez and K. Cho (2016, Submitted) Positive Trend in Sea Ice Extent in the Antarctic and associated Changes in Surface Temperature, *J. Climate.*

Turner, J., Hosking, J.S., Marshall, G.J., Phillips, T. and Bracegirdle, T.J., (2015) Antarctic sea ice increase consistent with intrinsic variability of the Amundsen Sea Low. *Climate Dynamics*,1-12. doi: 10.1007/s00382-015-2708-9

Comiso, J. C., R. Kwok, S. Martin and A. Gordon, (2011) Variability and trends in sea ice and ice production in the Ross Sea, *Journal of. Geophysical Research.*, 116, C04021, doi:1029/2010JC006391.

Comiso, J. C. (2015) Variability and trends of the Global Sea Ice Covers and Sea Levels: Effects on Physicochemical Parameters, In: *Climate and Fresh Water Toxins*, edited by Luis M. Botana, M. Carmen Lauzao and Natalia Vilarino, De Gruyter, Berlin, Germany. ISBN: 9783110333039 3110333031

Data Sources: Satellite Passive Microwave Data (NASA Nimbus-7 SMMR, DMSP SSM/I series of sensors from F8 to F17), and NOAA AVHRR series; NOAA-7, 9, 11, 13, 15, 18. The data have been assembled with quality control to ensure consistent values from the various sensors that make up the time series using funds provided by the NASA Cryospheric Science Program.

Technical Description of Figures:

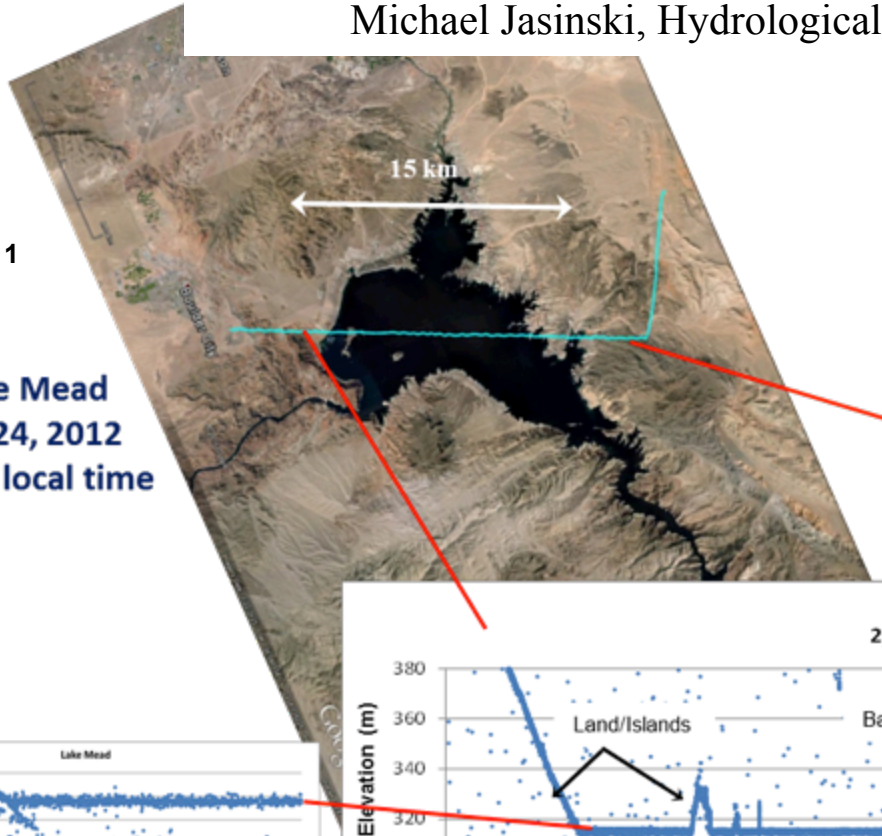
Figure 1: (left) shows monthly anomalies of ice extent from passive microwave data using a newly updated and enhanced version of the time series. The plot shows the interannual variability and a positive trend of 1.7% per decade with 2014 showing record high values. The trends in ice concentration are coherent with the trend in surface temperature as illustrated in **Figure 2** (middle) for the growing season in autumn. The figures indicates that areas where the trend is significantly positive for sea ice are also where the trend is significantly negative for surface temperature. Such coherence is an indication that the two variables are strongly related. The results of quantitative analysis as presented in **Figure 3** (right) shows that indeed the ice area is strongly correlated with surface temperature with the correlation coefficient being 0.94 with no lag and 0.96 with a one-month lag in surface temperature. The high correlations, especially with the lag, suggest that surface temperature has a strong influence on the changes in the extent of the sea ice cover.

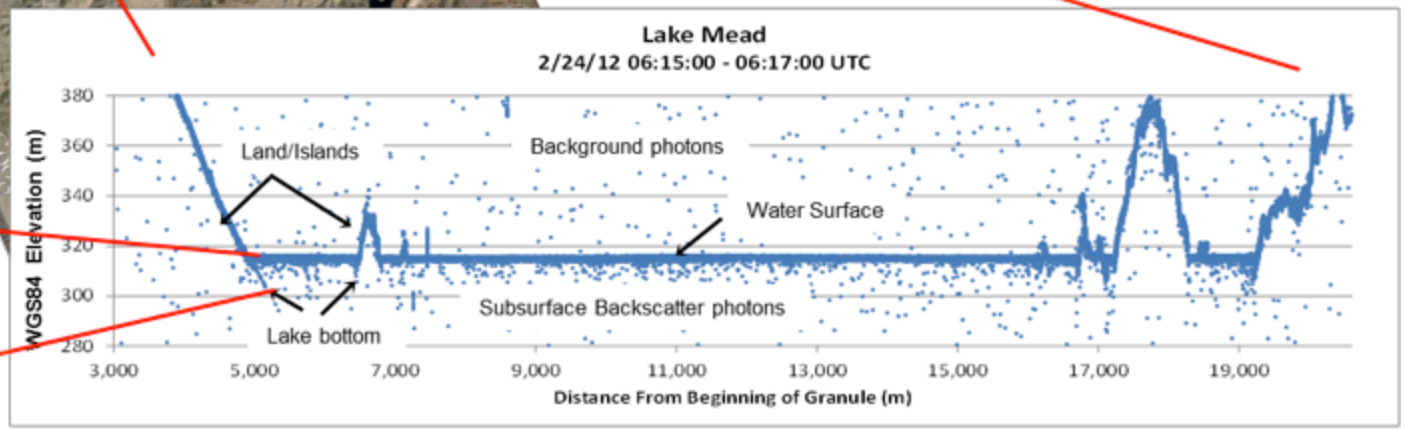
Scientific significance, societal relevance, and relationships to future missions: This research provides new insights into the observed positive trend in the Antarctic sea ice which has been used by skeptics as an indicator that there is no climate change. The global trend in surface temperature has a high spatial variability with the trends in the Arctic very positive and consistent with a rapid decline of sea ice in the region while in the Antarctic the trend is more modest and actually show some cooling in large areas where sea ice has been advancing. Results also reveal a very strong correlation of surface temperature with sea ice area indicating that the observed positive trend in the sea ice cover is consistent with the spatial distribution of global warming trend and hence the trend should not be regarded as unexpected. The reason why modeling studies show negative trends in the Antarctic sea ice extent and not positive as observed is likely because the models are not able to reproduce the spatial distribution of surface temperatures as observed by satellite data. The results are highly relevant to the goals of the NASA Earth Observing System Program and related to future missions such as the follow-on of SSM/I, AMSR2 and MODIS.

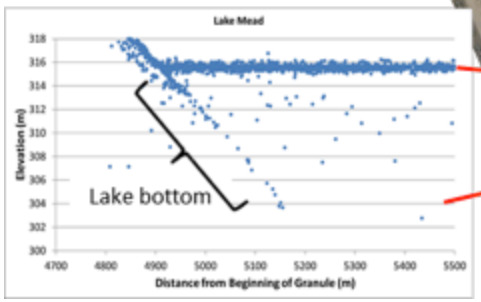
Profiling Inland Water Bodies from Above the Troposphere

Michael Jasinski, Hydrological Sciences, NASA GSFC

Figure 1







Prototype ICESat-2 observations with the high altitude Multiple Altimeter Beam Experimental Lidar (MABEL) demonstrate the feasibility of profiling water surface height statistics over inland and coastal waters.

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References:

Jasinski, M., Stoll, J., Cook, W., Ondrusek, M., Stengel, E. and K. Brunt. 2016. Inland and Near Shore Water Profiles Derived from the High Altitude, Multiple Altimeter Beam Experimental Lidar (MABEL), *Journal of Coastal Research*, in press.

Data Sources:. The current analysis evaluates data from the Multiple Altimeter Beam Experimental Lidar (MABEL), a prototype ICESat-2 instrument. Transects were observed from 20 km above ground over Lake Mead at 11 PM February 24, 2012 (UTC 2012-09-22T00:56). The transect, about 14 km in length, was acquired in about 1.5 minutes.

Technical Description of Figures:

Figure 1: In preparation for the ICESat-2 mission that will carry the Advanced Topographic Laser Altimeter System (ATLAS), MABEL was built and flown in high altitude aircraft experiments over a range of inland and near-shore targets. The purpose was to test the ATLAS concept and to provide a database for developing the ICESat-2 Inland Water Height Product or ATL13, an algorithm that estimates along track surface water height and light penetration under a range of atmospheric and water conditions.

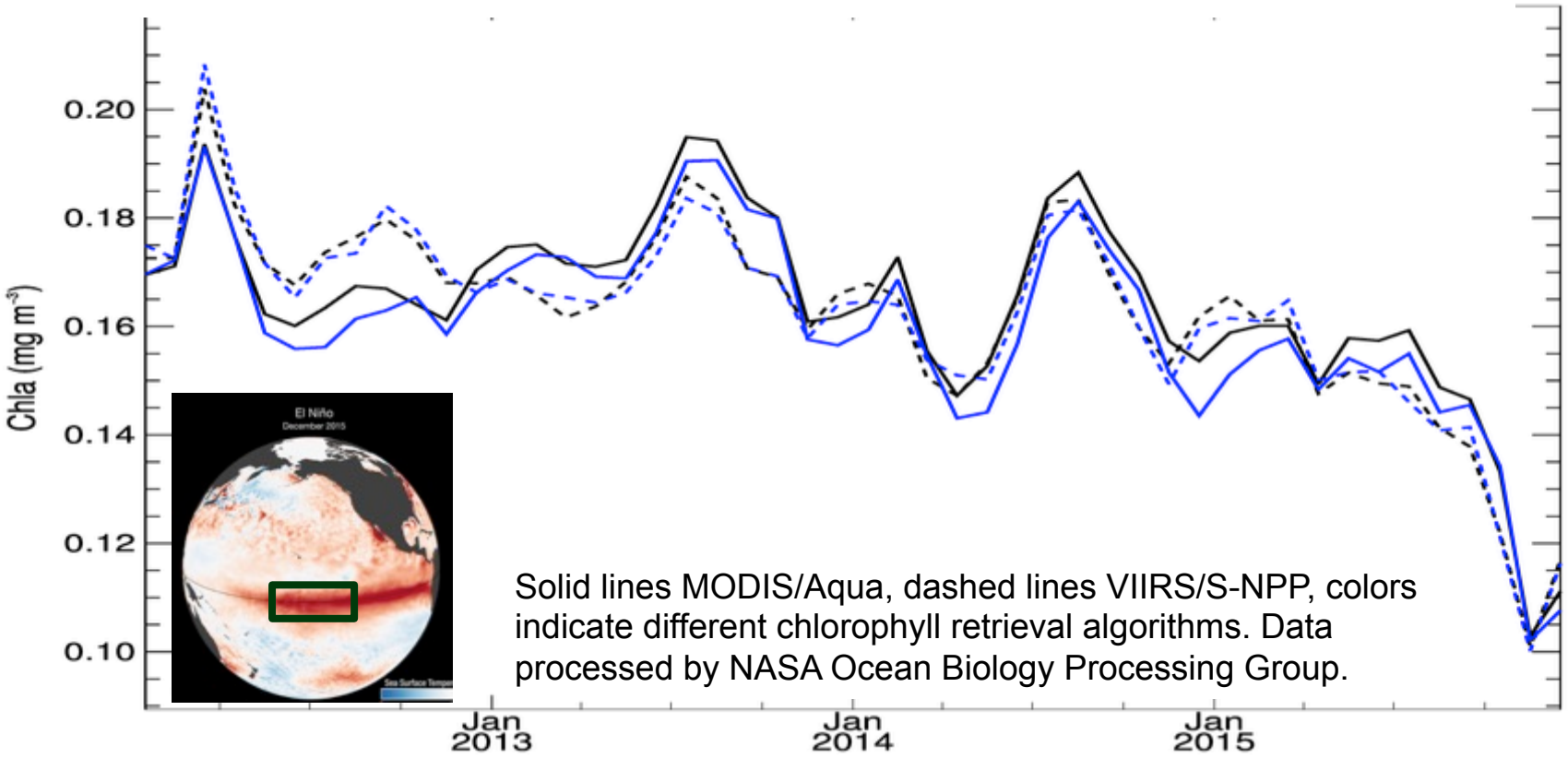
This case represents a MABEL night flight aboard NASA's ER-2 at ~ 20 km height over a relatively clear water body with turbidity equal to 1.6 NTU. The MABEL overpass of February 24, 2012 transected the western portion of Lake Mead in a Southwest to Northeast direction as shown in the figure. Each dot represents a photon returned to the MABEL detector. During the flight approximately 91,000 photons were recorded.

Several features are clearly identified. First, starting at the edge of the lake and traversing across, several islands are noted. To the far right of the figure, after passing over a large island nearly 60m high, the aircraft reaches the edge of the lake. Subsurface backscatter yields an estimated penetration depth of ~9m. The attenuation coefficient is estimated to be $a_{532} = 0.40\ m^{-1}$.

Scientific significance, societal relevance, and relationships to future missions: An Inland Water Height Product or ATL13 is being developed for the ICESat-2 mission. The overall positive results suggest that the feasibility of retrieving operational surface water height statistics from space-based photon counting systems such as ATLAS is very high for resolutions down to about 100m, even in partly cloudy conditions. The capability to observe subsurface backscatter profiles due to green light (532 nm) penetration is also achievable with longer transects. Results of this and other MABEL flights indicate it's high capability for retrieving surface water height statistics with a mean height precision of approximately 5-7 cm per 100m segment length.

Phytoplankton chlorophyll decline in equatorial Pacific associated with 2015 El Niño event

B. A. Franz, Ocean Ecology, NASA GSFC



Trends in ocean chlorophyll concentration, a proxy for marine phytoplankton abundance, shows ~40% decline for the equatorial Pacific, as observed by two different missions and two different chlorophyll retrieval algorithms. Decline is associated with a major El Niño event, which suppresses nutrient availability in the region.

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References:

Franz, B.A., D.A. Siegel, M.J. Behrenfeld, P.J. Werdell (2015). Global ocean phytoplankton [in State of the Climate in 2014]. Bulletin of the American Meteorological Society, submitted.

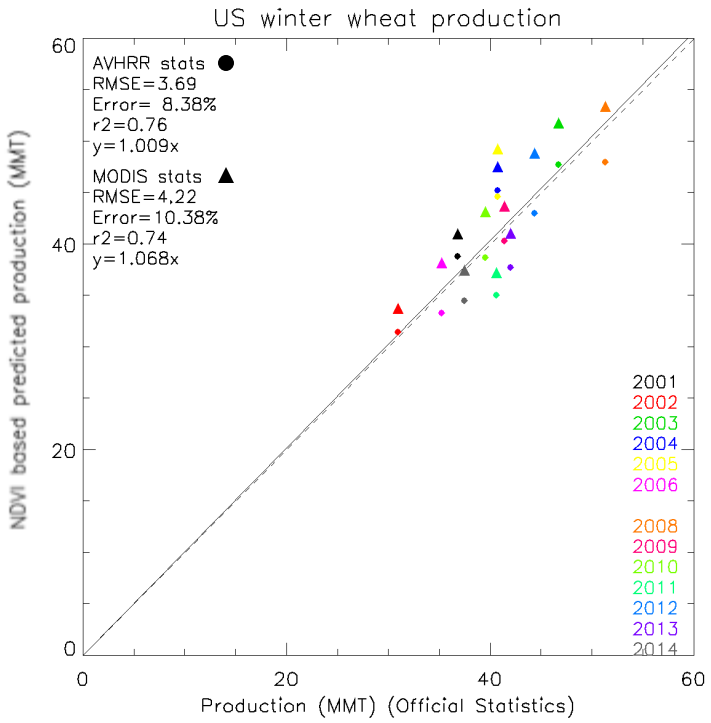
Data Sources: MODIS Aqua and S-NPP VIIRS ocean color data products processed by the Ocean Biology Processing Group, Ocean Ecology Laboratory (616), NASA Goddard Space Flight Center.

Technical Description of Figures: Trends derived by spatially averaging data over the El Niño 3.4 region of the equatorial pacific, as show in the lower left inset. Each point is a monthly mean. Data are shown for two different missions, independently processed, and two different retrieval algorithms (one a band ratio algorithm, another a band difference algorithm).

Scientific significance, societal relevance, and relationships to future missions: Results show a significant decline in phytoplankton abundance that can be associated with a decline in net primary productivity for a vast region of the world's oceans. Comparison with the long-term record suggests this is the largest one-year decline in phytoplankton abundance since 1997, when NASA first began routine observation of ocean biology on global scales with the SeaWiFS mission. The trend results also show remarkable agreement from two independent satellite sensors, which demonstrates the quality and consistency in the instrument calibrations and processing algorithms developed by NASA, and provides confidence in our ability to monitor long-term changes in ocean's biological response to climatic events across multiple mission lifespans. The future PACE mission will allow for the continuation of this time-series, and lead to deeper understanding of the relationship between the observed bio-optical signals and phytoplankton abundance, species shifts, and physiological state, and ultimately to more precise estimates of global net primary productivity.

A 30+ years AVHRR Land Climate Data Record

Eric Vermote, Terrestrial Information Systems, NASA GSFC



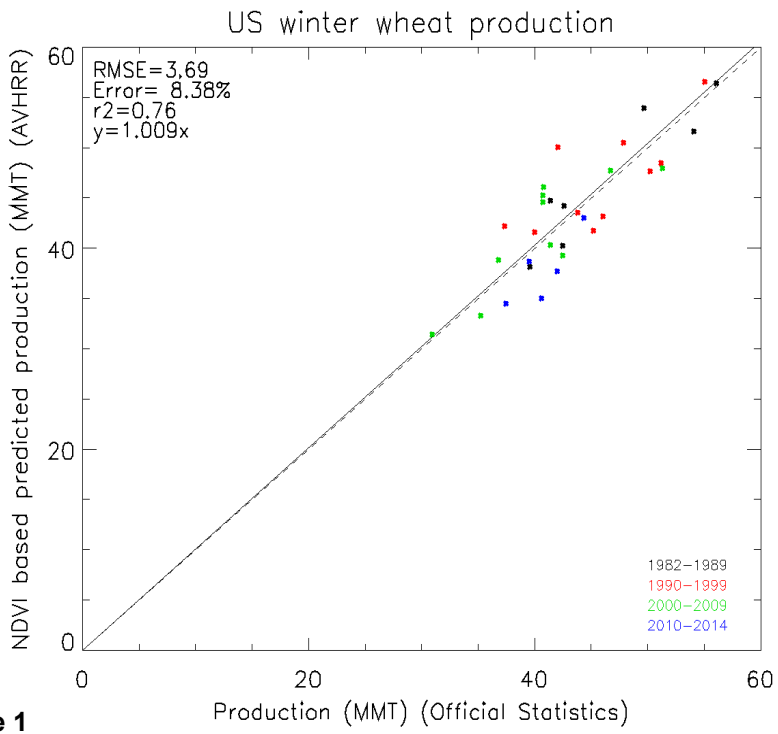


Figure 1

A consistent, validated 30+ year Land Climate Data Record from AVHRR including Surface Reflectance, Vegetation Index, Leaf Area Index and Fraction of Absorbed photosynthetic Radiation is now available to the public and has been shown to be accurate to within 10% in agriculture monitoring applications.

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References:

Becker-Reshef, I., Vermote, E., Lindeman, M. and Justice, C., 2010. A generalized regression-based model for forecasting winter wheat yields in Kansas and Ukraine using MODIS data. *Remote Sensing of Environment*, *114*(6), pp.1312-1323. doi:10.1016/j.rse.2010.01.010

Franch, B., Vermote, E.F., Becker-Reshef, I., Claverie, M., Huang, J., Zhang, J., Justice, C. and Sobrino, J.A., 2015. Improving the timeliness of winter wheat production forecast in the United States of America, Ukraine and China using MODIS data and NCAR growing degree day information. Remote Sensing of Environment, 161, pp.131-148. doi:10.1016/j.rse.2015.02.014

Claverie, M., Matthews, J.L., Vermote, E.F. and Justice, C.O., 2016. A 30+ Year AVHRR LAI and FAPAR Climate Data Record: Algorithm Description and Validation. Remote Sensing, 8(3), p.263. doi:10.3390/rs8030263

Data Sources: This study uses the AVHRR and MODIS daily Normalized Difference Vegetation Index produced by code NASA/GSFC 619.

Technical Description of Figures:

Figure 1: Left side shows on the y axis the MODIS (dots) and AVHRR (crosses) Normalized Difference Vegetation Index based prediction of the production of winter wheat for United States for the 2001 to 2014 period one month prior to harvest, the right side shows the same thing for AVHRR over the 1982 to 2014 period. The predicted production on the y-axis in Millions of Metric Tons (MMT) is compared to official reported yield in MMT (x axis).

Scientific significance, societal relevance, and relationships to future missions: Continuous, consistent and systematic high quality Earth observations from NASA/NOAA satellites provide the critical synoptic and objective information needed by applications of societal benefit in the context of growing population and climate change. Demonstrating how to use current sensors to understand our changing planet and delivering those data to the global community is critical to further improving decision-making by other government agencies and partner organizations in the areas of agricultural monitoring and food security.